TEST REPORT

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CORROSION RESISTANCE OF ANODIC COATINGS FOR ALUMINUM ALLOYS

by

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TABLE OF CONTENTS

OBJECT

To establish realistic performance and inspection test data for the determination of the corrosion resistance of anodic coatings upon aluminum using test procedures as specified in MIL-A 8625A and Federal Test Method Standard #151.

INTRODUCTION

The feasibility of using 5% or 20% salt fog as the corrosive media in evaluating the corrosion resistance of most metals and protective coatings for metals, has been under study by industrial and government organizations for some time. Extensive evidence of test results supports the conclusion that the 5% salt fog produces the more corrosive effects and is suitable for evaluating organic protectives on metals. Industry standardized on the 5% salt fog test as it is less expensive to operate and to maintain. Industry in general and government organizations now use the 5% salt fog as their testing media.

The aluminum industry, however, in evaluating corrosive resistance qualities of anodic coatings on aluminum panels, has utilized the 20% salt fog test for rating the protective value of the coating, with the protection rating indicated by either a loss in strength or the appearance of white corrosion products on the panel. For Ordnance application these corrosive products are harmful to the operation of equipment. Therefore the protective value is limited to the time period for the appearance of white spots.

STUDY

A. Pre-Test Preparations

1. Chamber:

The single salt fog chamber utilized for this series of tests was manufactured by the Industrial Filter & Pump Company of Chicago, and it was operated in compliance with all the requirements of Federal Test Methods Standard No. 151, Method 811.

The interior working space of the cabinet was 25" x 34" to the left of the salt solution reservoir, and the panels under exposure were on the same level as the salt fog nozzle.

2. Panels:

Five hundred (500) panels were obtained from the "Q" Panel Co., Cleveland 11, Ohio, of #2024 Aluminum alloy prepared in conformance to specifications QQ-A-335 and MIL-A-8625. The panel dimensions were changed to 3" x 6" x 0.20" prepared as follows:

(a) 200-Chromic Acid Anodized; coating 0.00020" (average).
(b) 200-Sulfuric Acid Anodized; coating 0.00025" (average).
(c) 100-Un-anodized; to be used as blank controls.

The coating thickness was determined by a metallographic examination of representative specimens, and indicated the minimum permissible coating thickness.

3. Panel Identification:

All panels were Vibro-Tool engraved on their reverse side for permanent identification. Additional information was added to each panel as appropriate. Ultimately each panel was completely identified to indicate type of anodizing (i.e. C for Chromate, S for Sulfuric Acid, and B for blank), chronologically numbered from 1-200 in S and C groups, 1-100 in B group, 5-I, 5-II, 20-I, 20-II, representing salt fog concentration and test run, and a number representing the number of exposure hours.

4. Panel Supports:

To support the panels at a 6° angle within the chamber, wooden blocks 3½" x 13" x 2" were secured, with ½" deep cuts 7/8" on center across the 3½" face of each block. The 7/8" spacing assure that no salt fog condensate would drip off of one panel onto one adjacent.

It was not possible, however, to obtain these cuts 0.022-0.025" as desired, and they were slotted to approximately 1/8 (0.125"). This necessitated backing-up each panel with cardboard to prevent its tipping within the slot. If during exposure the cardboard failed to hold a panel tightly against one wall of the slot, the angle would have varied, and an erroneous factor introduced into the experiment.

During each of the four (4) exposures ten blocks were used, each holding ten (10) panels in the ratio of 4S-4C-2B.

B. Test Procedure

MIL-A-8625A requires an exposure period of 240 hours. Four series of exposures were performed, in order, as follows:

1. 20%-I (354 hours).

2. 5%-I (330 hours).

3. 20%-II (212 hours; stopped because of a holiday).

4. 5%-II (264).

5. 20%-III (a few panels to obtain withdrawals missed during 20%-I).

Location of the panels in the cabinet, and withdrawals, were made at random; but withdrawals were in the 2C-2S-1B ratio.

Withdrawals were made approximately every 24 hours. Panels were rinsed in 100°F water without rubbing panel surface and immediately placed in a 200°F oven to dry. Panels were then individually wrapped in onion skin paper and stored in a desiccator until ready for evaluation of damage.

C. Evaluation of Results

1. Visual Observation:

Upon completion of the four exposures, the panels were removed from the desiccator in a constant temperature air-conditioned laboratory area. Each panel was so displayed that it was possible to observe simultaneously the results of each exposure run, for any similar number of hours, and for each type of anodic coating.

In accordance with MIL-A-8625A, the appearance of three or more corrosion spots on a panel constitutes a failure. Panels were categorized upon examination as follows:

Category A. 0-3 spots
Category B. 4-10 spots
Category C. 11 or more spots

The examination was made within a panel area of 3/4" from top and bottom, and ½" from each side. The results averaged as follows:

	20	40	60	80	100	120	140	160	180	200	220	240
20% I C	A	A	A	B	C	C	C	C	C	C	C	C
20% I S	A	A	A	B	C	C	C	C	C	C	C	C
20% II C	B	B	B	B	B	B	B	B	B	B	B	B
20% II S	C	C	C	C	C	C	C	C	C	C	C	C

	20	40	60	80	100	120	140	160	180	200	220	240
5% I C	A	B	C	C	C	C	C	C	C	C	C	C
5% I S	A	B	C	C	C	C	C	C	C	C	C	C
5% II C	A	A	A	A	A	A	A	A	A	A	A	A
5% II S	C	C	C	C	C	C	C	C	C	C	C	C

2. Tensile Properties:

(a) Duplicate tensile specimens were machined from the chromate and sulfate coated panels. The specimens had a 1" gage length and ½" width.

(b) The test results and the exposure condition for the samples are as shown:

Tensile Properties of Panels

	Hours Exposure	Ultimate Tensile Strength psi	% Loss	Elongation %	% Loss	Salt Fog Concentration
Chromate	0	66400		14.2		None
	242	66000	0	15.0	0	5%
	257	65200	1.8	15.2	0	20%
Sulfate	0	66400		15.5		None
	242	65200	1.8	15.2	1.9	5%
	257	65700	1.0	14.9	3.8	20%

NOTE: The change in mechanical properties due to exposure is indicated as a percentage. A reduction of five per cent in tensile strength or ten per cent in elongation is permitted for an exposure of 240 hours in a salt fog test. The panels complied with specification requirements.

D. Evaluation of Results

1. Surface Corrosion Spots:

Most specimens were badly corroded after 240 hours in the 5% and 20% Salt Fog Chamber, but still complied with the mechanical properties required by the specification MIL-A-8625A. Most panels had corroded areas in less than 40 hours with exposure to either 5 or 20% salt fog.

E. Conclusions

Neither the Chromic Acid nor the Sulfuric Acid Anodizing to a minimum thickness is sufficient to protect aluminum against corrosion products formed upon exposure to both 5% and 20% salt fog, within the limits of MIL-A-8625A, although of sufficient thickness to permit compliance with tensile test requirements.

F. Recommendations

1. No revision of the specification is recommended at this time, in as much as the minimum thickness anodized coating satisfies tensile strength requirements. A heavier anodizing is necessary to satisfy the corrosion requirements.

2. An additional series of tests is recommended to compare the effect of 5% and 20% salt fog on aluminum anodizing, taking sufficient time and precautions to eliminate some of the potential variables. Further considerations:

(a) Increase anodizing thickness, and assure uniformity of application.

(b) Utilize similar areas within salt spray chamber.

(c) Make precision-cut 6^{o} slots to support test specimen.

(d) Make more frequent examination and removal of specimen.

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